

## Executive Summary

On the afternoon of September 11, 1992, a small but intense Hurricane Iniki struck Hawaii across the island of Kauai. With damage estimates of \$1.8 billion, this was one of the most destructive hurricanes on record anywhere in the United States. Seven persons died and about 100 were injured because of Iniki. However, because of the in-place warning system and the response of the populace, a greater human tragedy was averted.

Overcoming limitations in satellite coverage and with negligible surface observations, CPHC forecasters alerted the populace of Hawaii a day in advance that the storm would hit the state. The state and local emergency services organizations, the media, and the populace all responded quickly and appropriately. In short, the system worked.

Although hurricanes are common in the eastern Pacific Ocean, and not uncommon in central Pacific Ocean, they usually either remain well east of or cross south of the Hawaiian Islands. This was only the fourth time in the past 40 years that the state has been hit by such a storm. Despite this relative rarity, all involved were generally well prepared for the event. Some of this can be attributed to the well-publicized comparisons and similarities between Iniki and Hurricane Andrew that affected Florida and Louisiana shortly before Iniki formed.

There were, however, several problems identified that had the potential to severely impact the alert system. These include:

1. Communications. The reliance by all involved on telephone communications is probably the most critical of the problems uncovered. Backup, stand-alone communication's links, a more efficient method for interacting with the media and the general public, and a faster, more reliable way for hurricane forecasters to receive forecast guidance products are the most pressing issues.
2. Observations. With only one geostationary satellite covering the water areas south and east of Hawaii, there is an absolute necessity of making backup observational systems (especially polar orbiting satellite data) available to the hurricane forecasters. Had the one geostationary satellite failed, it is likely the warning time achieved would have been greatly reduced.
3. Capabilities of the CPHC. The forecasters are hampered by old computer and word processing equipment. Also, a greater level of expertise could be attained by specifying selected individuals from the Honolulu forecast office to staff the Hurricane Center and providing them with additional, ongoing training.
4. Navy Relations. The CPHC has total responsibility for tropical cyclone warnings in the central Pacific area. Because the United States military, specifically the Navy, has such a significant presence in the Pacific, it has a vital concern when such storms threaten Hawaii, especially Oahu. The interactions and information flow between the two organizations must be smooth so that the requirements of the Navy are known and addressed and the capabilities of the Navy are used to the advantage of the CPHC.

# Findings and Recommendations

## Chapter 1. The Event and its Impact

### Finding 1.1

A small but intense hurricane struck the state of Hawaii during the afternoon of September 11, 1992. Although all islands felt the storm, the islands of Kauai and Oahu were most impacted. Seven persons were killed and about 100 injured; total damage was about \$1.8 billion. The south shore of Kauai near Port Allen took the brunt of the storm with wind gusts measured to 143 miles per hour (MPH) and water levels (a combination of storm surge and waves) nearly 30 feet above normal.

### Finding 1.2

Because of the apparently weak construction of many buildings, estimates of wind speed based on building damage may be unreliable. Estimates based on other indicators showed sustained winds of 130 to 160 MPH especially in areas where winds are enhanced by terrain.

### Recommendation 1.2.1

The NWS should encourage the State of Hawaii to review its building codes in light of the Iniki damage.

## Chapter 2. Scientific Analysis of the Event

### Finding 2.1

Many objective hurricane forecast aids were available to CPHC forecasters. However, the communications links for receiving these products were cumbersome.

### Recommendation 2.1.1

The NWS should review the methods by which CPHC forecasters receive guidance products to see if they can be delivered in a more timely and efficient manner. Some suggestions on this include:

- a) revamping the ways model input/output both to/from the NHC is transmitted to make it more efficient,
- b) upgrading the computer capabilities and adding available software packages such as the Automatic Tropical Cyclone Forecast (ATCF) system, and
- c) evaluating the feasibility of developing objective inland and coastal flood models for Hawaii.

### Finding 2.2

The utilization of the available guidance products was limited because complete documentation was not available to CPHC forecasters and because model comparisons and error evaluations were not routinely done.

#### Recommendation 2.2.1

The NWS management should enhance the capabilities of the CPHC staff by:

- a) providing the CPHC with current written descriptions of all available forecast tools (e.g., up to date, complete documentation on the dynamic and analog/climatological models), and
- b) requiring that model comparisons and forecast error evaluations become a regular part of the CPHC forecast operation.

### **Chapter 3. Data Acquisition and Availability**

#### Finding 3.1

Not all available analysis products, specifically the Deep Layer Mean Winds and Wind Shear Analysis, adequately cover the CPHC area of responsibility.

#### Recommendation 3.1.1

The NMC should extend the Deep Layer Mean Winds and Wind Shear Analysis west to the International Dateline.

#### Finding 3.2

The satellite unit at CPHC provided an invaluable service to the forecasters and to the public by determining and monitoring storm position and movement throughout Iniki's life cycle.

#### Recommendation 3.2.1

NWS management should insure that the satellite section currently in place be retained.

#### Finding 3.3

CPHC has no direct access to polar orbiting satellite data. The only backup for the one Geostationary Operational Environmental Satellite (GOES) capability available to the CPHC is provided by copies of polar orbiting satellite photographs sent (as time allows) from the Hickam Air Force Base weather facility.

#### Recommendation 3.3.1

The NWS should expedite the installation of systems, such as the High Resolution Picture Transmission Information Processing System (HIPS), to provide the CPHC with direct access to polar orbiting satellite data. Also, the NWS should consider providing the CPHC with capabilities for archiving selected GOES photographs and for directly accessing other data available via satellite. This would include tide gage data currently available from the GOES.

#### Finding 3.4

Although Iniki passed between the existing data buoy network south and west of Hawaii, the sea height information provided by this network was the only real-time data available and allowed CPHC forecasters to make reasonable coastal sea height forecasts.

### Finding 3.5

Communications between Kauai and the rest of the state depend primarily on telephone links. Because these failed, no observations (or other reports) were available from Kauai to CPHC forecasters during the period of time beginning over 2 hours before Iniki hit and lasting several days until local power and telephone communication links were restored and a NWS electronics technician (ET) was able to get to Lihue.

#### Recommendation 3.5.1

The NWS should require installation of reliable, independent, backup communications with the Weather Service Office (WSO) in Lihue (and other Hawaiian WSOs).

#### Recommendation 3.5.2

The NWS needs to improve the arrangement for providing ET services at WSO Lihue.

### Finding 3.6

Upper air observations were not made by WSO Lihue from the afternoon on September 11, 1992 through the morning of September 14, 1992.

#### Recommendation 3.6.1

The NWS needs to implement a policy that, except when safety considerations prevent, upper air soundings and other observations be taken at NWS facilities even though communications are disrupted.

### Finding 3.7

During the recovery from **Iniki**, manual methods for taking temperature and humidity readings had to be made because power to the primary observing system was shut off by airport management.

#### Recommendation 3.7.1

The NWS should require that all critical observing systems have reliable backup power preferably under NWS control.

### Finding 3.8

Radar information from **Hickam** Air Force Base, Kokee Air National Guard Base, and the Federal Aviation Administration provided some helpful information to CPHC forecasters.

## **Chapter 4. Preparedness**

### Finding 4.1

The responsible agencies of Oahu and Kauai were very well prepared.

### Finding 4.2

The preparedness of the CPHC was somewhat hindered because it is staffed on a generally ad hoc basis from personnel assigned to WSFO Honolulu.

#### Recommendation 4.2.1

NWS management should consider modifying the organization of CPHC to increase the capabilities and expertise of the unit. Suggestions to implement this include:

- a) identifying a specific group of forecasters from WSFO Honolulu as members of the CPHC and providing this group with annual training possibly conducted by NHC,
- b) identifying one member of this unit as a Warning Preparedness Meteorologist (WPM) focal point (not a program leader), and
- c) investigating the advisability of increasing the direct contacts and interactions between the CPHC staff and hurricane specialists from the NHC.

#### Finding 4.3

The back-up plans for WSFO Honolulu would not have worked as written.

#### Recommendation 4.3.1

NWS management should see that the backup program for WSFO Honolulu is reviewed and necessary modifications implemented.

## **Chapter 6. Warning Services**

#### Finding 5.1

The people of Hawaii were sufficiently warned.

#### Finding 5.2

The practice of downgrading the hurricane warning to a tropical storm warning or watch as **Iniki** was departing caused some confusion as to whether a second storm was approaching Hawaii.

#### Recommendation 5.2.1

CPHC should re-evaluate the procedures forecasters use when downgrading tropical storm and hurricane warnings.

#### Finding 5.3

The use of probability cones or ellipses would be desirable, especially to the United States Navy (USN).

#### Recommendation 5.3.1

The CPHC should consider including probability cones or ellipses for all tropical cyclone marine and public advisories.

## **Chapter 6. Coordination and Dissemination**

#### Finding 6.1

Dissemination of NWS products to various user groups was sufficient but very labor intensive, relying greatly on commercial telephones and old word processing equipment.

#### Recommendation 6.1.1

CPHC management should consider alternatives to the current practice of having the duty CPHC forecaster answer telephone calls from users. Some suggestions include:

- a) staffing CPHC with a sufficient number of people to field media and public queries and thus allow forecasting personnel to concentrate on operational duties,
- b) dedicating specific hotline telephone numbers for the media only and for emergency officials only,
- c) when weather becomes critical, providing briefings to the media on a scheduled, frequent (e.g., hourly) basis,
- d) consider holding a workshop to sensitize the media to the process of tracking and forecasting tropical cyclones and of the times when the forecasts are updated, and
- e) conducting all in-house briefings in the media briefing room and not the forecast area.

Recommendation 6.12

The NWS should replace the PRIME/TAB terminals used by CPHC forecasters for message composition with an up-to-date system.

Recommendation 6.1.3

NWS/CPHC Management should consider enhancing CPHC capabilities by:

- a) reviewing the station's alerting procedures to see if a more efficient initial dissemination process can be developed, and
- b) establishing a Pacific Coordination Hotline similar to that currently serving the mainland United States.

Finding 6.2

It was very important to all users that the hurricane products for the central Pacific originate in Hawaii.

Recommendation 6.2.1

The DST suggests that, taking into account the available expertise within the agencies involved, the geography of the Pacific Basin, and the government's changing fiscal climate, a detailed look at the hurricane warning structure in the Pacific, involving the USN, United States Air Force (USAF), and NWS, be undertaken. In so doing, the DST affirms its belief in the importance of having a separate hurricane center in the Pacific.

Finding 6.3

NOAA Weather Radio (NWR) transmitters in Hawaii are operated through one central transmitter. Iniki knocked this station out eliminating the other stations as well.

Recommendation 6.3.1

The NWS should review the current NWR system to see if an alternative can be arranged whereby all NWR transmitters in Hawaii function independently.

#### Finding 6.4

The Naval Western Oceanography Center (NAVWESTOCEANCEN) in Hawaii, which relies on CPHC hurricane products, has special requirements for performing its mission. Similar special criteria are important to the state emergency services agencies.

##### Recommendation 6.4.1

The CPHC should elicit from users critical wind and sea height values and should highlight these in appropriate tropical cyclone products.

##### Recommendation 6.4.2

Better rapport needs to be developed between CPHC and NAVWESTOCEANCEN.

#### Finding 6.5

Several tropical cyclone products important to mariners were not broadcast by the United States Coast Guard (USCG) communications station (COMSTA) on Oahu.

##### Recommendation 6.5.1

The NWS should review the list of products broadcast by the USCG COMSTA in Hawaii. Tropical cyclone marine advisories should be added to the list.

### **Chapter 7. User Response**

#### Finding 7.1

By and large, the populace of Hawaii responded appropriately to the hurricane warnings. Designated shelters were known and used. However, in several cases, the shelters, though appropriate for tsunamis, were not appropriate for hurricanes.

##### Recommendation 7.1.1

The NWS should encourage the State of Hawaii to review its criteria for disaster shelters to make them more appropriate for hurricanes. Expanded criteria may exclude facilities where the room ceiling is also a roof and rooms with windows from being a shelter.

#### Finding 7.2

People on Kauai ignored hurricane warnings unless accompanied by the sounding of a siren. They then took action promptly.

##### Recommendation 7.2.1

The NWS, in coordination with Hawaiian Civil Defense officials and with the help of the media, should conduct a public awareness campaign to educate the public on the importance of watches and warnings not accompanied by sirens.

### **Additional. Disaster Survey Team Management**

#### Finding 8.1

During its investigation, the DST was impacted by in-place policies and procedures that, if changed, could improve the conduct of future surveys.

Recommendation 8.1.1

NOM and NWS procedures for putting together a DST should be annotated to suggest that it is not advisable to have a member of the DST be from the local office that was involved with the event.

Recommendation 8.1.2

NOAA should consider assigning responsibility for coordinating disaster survey overflights to the OFCM.